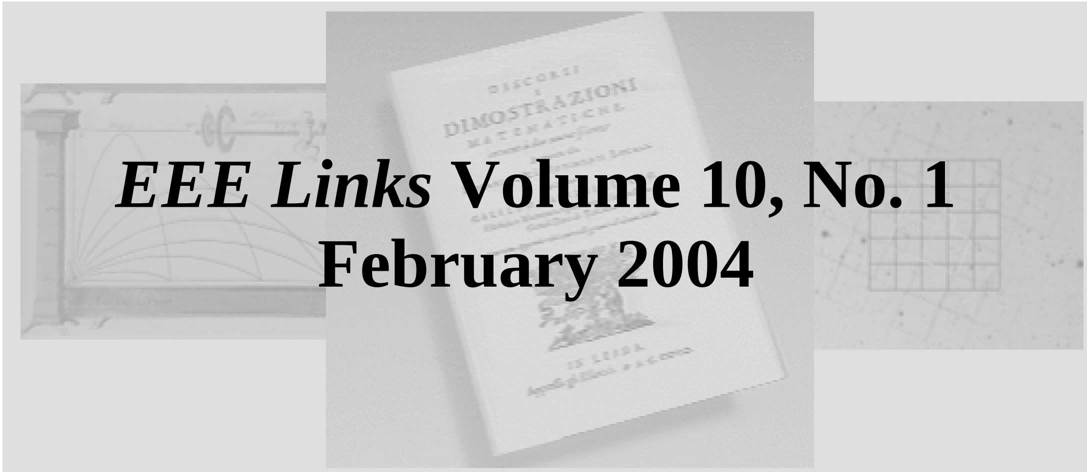

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Letter From the Editor

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Welcome to the February 2004 issue of *EEE Links*. The expert interview with Ken LaBel, Radiation Effects and Analysis Leader for Code 561, introduces this year's NASA Electronic Parts and Packaging Program focus: Body of Knowledge (BOK) and Technology Readiness Overview (TRO) tasks. Following Ken's explanation of what BOK and TRO tasks encompass, and what their value is to the program and to NASA, each task is described along with its benefits to NASA and point of contact.

In this issue, there is a special feature on how to get your username and password for accessing the GIDEP, CALCE, and MAPTIS Web sites. These are valuable resources for NASA parts engineers, as they include information on part reliability and quality, issues and failures, analysis tools for validating packaging designs, and materials data.

Also appearing in this issue are a description of recent changes to the NEPP Web site, an article on the Government Electronics and Information Technology Association (GEIA) Overview and January 2004 Committee Meeting Highlights, and WebEx News, a feature about the NEPP Knowledge Sharing Program's virtual conference series.

Many thanks are extended to everyone who contributed to this issue. Please send questions, suggestions, and comments about the newsletter and its topics to my e-mail address cited above, or contact me by telephone Monday through Friday between 8:30 a.m. and 5:30 p.m. EST.

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Guidelines for *EEE Links* Article Submission

EEE Links is a quarterly publication. The next publication date and focus will be:

April 2004/NEPP's University Partners and Collaborators
Article submission deadline is March 31, 2004

EEE Links publishes many types of articles relevant to electronic parts, packaging, and radiation. Primary consideration is given to articles that relate specifically to the NEPP Program, but we also consider articles outside of the NEPP Program that address electronic parts, packaging, or radiation issues.

Articles can be informal and be from one paragraph to three pages in length on the following subjects:

- Current events within the NEPP Program and projects.
- Parts.
- Packaging.
- Radiation.
- Reliability issues concerning NEPP.

- New/emerging technology.
- Space flight hardware.
- Quality assurance issues.

To submit an article, please send it in a text-only format, preferably Microsoft Word, to Jeanne Ilg at jilg@qssmeds.com. Please provide the following information with your article submission:

- Abstract: This two- to four-sentence paragraph summarizes the key points to capture the reader's attention.
- Contact Information: The author must include his or her business address, phone, fax, and e-mail address.
- Notes and References: Most articles require some references, and some contain incidental information best treated as notes. Use brackets for references and superscripts for notes, then list the two groups separately at the end of the article. These should be numbered in the order in which they appear in the article, not alphabetically.
- Additional Reading: Our readers appreciate pointers to relevant books and articles. List these at the end of the article in the same format as the references.
- Copyright: The author is responsible for obtaining any copyright releases or other releases necessary for their article. The releases should be forwarded to the *EEE Links* Editor (see Jeanne Ilg's e-mail address above).
- Biography (to be supplied when requested): This should be between 50 and 75 words outlining the author's job, background, professional accomplishments, and other pertinent accolades or areas of interest. Accompanying photographs might be requested also; these should either be in .gif or .jpg format if possible.

Letters to the Editor

Please limit letters to 250 words. Include your name, phone number, and e-mail address. Names are withheld from publication upon request. We reserve the right to edit for style, length, and content.

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Upcoming Events

*For calendar updates on the NEPP Web site, go to http://nepp.nasa.gov/index_nasa.cfm/485/.

Microwave Radiometry and Remote Sensing Applications
February 24-27, 2004, Rome, Italy
For details, contact Gianna Calabresi, microrad04@mail.die.uniroma1.it, 39.06.44585406, or see event Web site http://www.die.uniroma1.it:8080/

2004 IEEE Aerospace Conference
March 6-13, 2004, Big Sky, MT
For details, contact David Woerner, David.F.Woerner@jpl.nasa.gov, 732.981.0060, or see event Web site http://www.aeroconf.org/

Extreme Environment Electronics Workshop
March 22, 2004, CALCE Electronic Products and Systems Center, University of Maryland, College Park, MD
For details, contact Ania Picard, appicard@calce.umd.edu, 301.405.5323, or see event Web site http://www.calce.umd.edu

5th International Symposium on Quality Electronic Design, ISQED 2004
March 22-24, 2004, Double Tree Hotel, San Jose, CA
For details, contact Susan Salera, isqed@isqed.org, 408.453.4000, or see event Web site http://www.isqed.org/registration.htm

IEEE SoutheastCon 2004 Professional Conference
March 26-28, 2004, Greensboro Downtown Marriott, Greensboro, NC
For details, contact Chip Dawson, c.t.dawson@ieee.org, 732.981.0060, or see event Web site http://www.ewh.ieee.org/cmte/secon04/

Capacitor and Resistor Technology Symposium (CARTS)
March 29, 2004, Sheraton Gunter Hotel, San Antonio, TX
For details, contact L. Hamiter, LHamiter@cti-us.com, 256.536.1304, or see event Web site http://www.cti-us.com/ucartsmain.htm

Aerospace Testing Expo 2004
March 30, 2004, Hamburg, Germany
For details, contact Aerospace Testing Expo 2004, info@ukintpress.com. 44(0)1306.743.744, or see event Web site http://www.aerospacetesting-expo.com/contact.html

AIAA International Air and Space Symposium 2004
April 19-21, 2004, Washington Court Hotel, Washington, DC
For details, contact Duane P. Andrews, www.airandspacesymposium.com/, 202.628.2100, or see event Web site http://www.airandspacesymposium.com/

Call for Papers, 9th Annual Automotive Electronics Reliability Workshop
April 20-22, 2004, Sheraton Music City Hotel, Nashville, TN
For details, contact Brian Jendro, bj5@dcx.com, 256.464.2980, or see event Web site http://www.aecouncil.com/index.html

International Reliability Physics Symposium (IEEE)
April 25-29, 2004, Hyatt Regency Phoenix at Civic Plaza, Phoenix, AZ
For details, contact Carole D. Graas, graas@us.ibm.com, 802.769.1214, or see event Web site http://www.irps.org/

Announcement and Call for Papers, Ceramic Interconnect Technology: The Next Generation II
April 27-28, 2004, Hyatt Regency Denver, Denver, CO
For details, contact IMAPS, imaps@imaps.org, 202.548.4001, or see event Web site http://www.imaps.org

Fourteenth Biennial Single Event Effects Symposium
April 27-29, 2004, Manhattan Beach Marriott, Manhattan Beach, CA
For details, contact Donna Cochran, dcochran@pop700.gsfc.nasa.gov, 301.286.8258, or see event Web site http://radhome.gsfc.nasa.gov/radhome/SEE/seesym.htm

ISCAS 2004: IEEE International Symposium on Circuits and Systems
May 23-26, 2004, Sheraton Vancouver Wall Center Hotel
For details, contact ISCAS, organizers@iscas2004.org, 256.536.1304, or see event Web site http://www.iscas2004.com/

2004 41st Design Automation Conference
June 7-11, 2004, San Diego, CA
For details, contact Kevin Lepine, kevin@mpassociates.com, 303.530.4562, or see event Web site http://www.dac.com/41st/index.html

Magnetics 2004, Advancements in Magnetic Applications, Technology, and Materials
June 9-10, 2004, Denver Marriott Tech Center, Denver, CO
For details, contact Jeremy Martin, Jeremym@infowebcom.com, 720.528.3770, extension 118, or see event Web site http://www.magneticsmagazine.com

Engineering of Reconfigurable Systems and Algorithms (ERSA '04)
June 21-24, 2004, Monte Carlo Resort, Las Vegas, NV
For details, contact Dr. Toomas P. Plaks, plakst@sbu.ac.uk, +44(0)20.7815.7495, or see event Web site http://www.scism.lsbu.ac.uk/ERA/ersa04/ersa04.html

IMAPS Topical Workshop and Exhibition on Flip Chip Technologies
June 21-24, 2004, Marriott Hotel, Austin, TX
For details, contact Ted Tessier, tessiert@statsus.com, 480.222.1735, or see event Web site http://www.imaps.org/abstracts.htm

National Space & Missile Materials Symposium
June 21-25, 2004, Doubletree Hotel Seattle Airport, Seattle, WA
For details, contact Michelle Kubal, mkubal@anteon.com, 937.254.7950, ext. 1168, or see event Web site http://www.usasymposium.com/nsmms/default.htm

Call for Papers, 2004 Electrostatics Society of America Annual Meeting
June 23-25, 2004, Rochester, NY
For details, contact Kelly Robinson, kelly.robinson@kodak.com, 585.477.4951, or see event Web site http://www.electrostatics.org/Announcements/20049620Call-For-Papers.htm

Call for Papers, 7th MAPLD International Conference
September 8-10, 2004, Ronald Reagan Building and International Trade Center, Washington, DC
For details, contact Rich Katz, mapld2004@klabs.org, 301.286.9705, or see event Web site http://klabs.org/mapld04/admin/cfp.html

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Changes to the NEPP Web Site

The NEPP Web site, http://nepp.nasa.gov, is a dynamic site in many ways. Its architecture allows our system administrator and software programmer to store all of the information as content, which is then displayed as needed, automatically updating itself as users upload documents and new events, or when other information is changed. The staff who implements the Information Management and Dissemination (IMD) task also regularly make changes to bring visibility to new information, to ease use of the site, or to comply with new requirements and standards.

Some of the most recent changes to the NEPP Web site lie in both of these areas. When you first go to the site, you will find a pop-up advertising the next WebEx conference. Please register and join us for this event. It will be a chance for you to listen to and ask questions of Dr. Reza Ghaffarian, NASA's leader in the research of area array interconnect technology.

New events and documents have been uploaded. These can be viewed by clicking on the Publications link on the left sidebar. This will produce a new sidebar that contains publication links, such as the *EEE Links* archive and the publications search tool. Now click on the sidebar link Display Latest Documents. A list of documents by date will be displayed in the main window.

Important Note: The main navigation tool for the NEPP Web site is the menu on the left sidebar. This sidebar will change as you navigate through the site. Your path is displayed just above this sidebar as a reminder of where you have gone.

With the programmatic changes to the NASA Electronic Parts Assurance Group (NEPAG), the NEPAG links on the NEPP site have become more comprehensive. You can access the NEPAG information either through the link on the sidebar at the main page or by going directly to http://nepp.nasa.gov/nepag/index.htm. Plans are still in progress for managing the information that had been contained in the restricted area on the prior NEPAG site, and so it will not be found in the NEPAG site's new location.

Plans are in process for augmenting the NEPP Web site with the One NASA header format. This change is expected to be in place by the release of the next issue of *EEE Links*.

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Special Feature: How To Get Your Username and Password for GIDEP, CALCE, and MAPTIS Web Sites

NASA parts engineers are greatly aided in their work through the use of a host of information technology-enabled data and content repositories. Among these are databases, Web sites, and information and press releases through automated e-mailings. The Information Management and Dissemination project through the NASA Electronic Parts and Packaging Program provides, through this periodical and through its Web site http://nepp.nasa.gov, information about these data sources and how to use them.

The Government Information and Data Exchange Program (GIDEP) is probably one of the oldest repositories of reliability and quality data regularly used by parts engineers. Though its content covers a wide range of commodities (electrical, mechanical, and chemical), a considerable amount of it is about problems, issues, or failures encountered with electronic parts used by the high-reliability community. This information, which is closely linked to military and space technology, is considered to require control in accordance with the International Trade in Arms Regulation (ITAR), and so it can be accessed only with a username and password.

The Computer Aided Life Cycle Engineering (CALCE) Web site, located at the University of Maryland, College Park, is also largely limited to holders of usernames and passwords. This is not because the information is considered ITAR controlled but because the content is paid for through the member-driven CALCE consortium. NASA, through the NEPP Program, purchases a membership in the consortium, yearly, for the benefit of NASA engineers and NASA's contractors. The Web site provides general information about electronic parts and their failure mechanisms and analysis tools for validating and studying electronic packaging designs.

The goal of the Materials and Processes Technical Information System II (MAPTIS) is shown on the homepage and is to be "a single-point source for materials properties for NASA and NASA associated contractors and organizations. The MAPTIS-II system contains physical, mechanical, and environmental properties for metallic and non-metallic materials." The primary data is contained in database records called reports, which have several searchable fields depending on the type of report it is. The searchable fields are shown as pull-downs when the user clicks the data type from the drill-down menu at the left of the site. The type of data is divided by metals and non-metals and each by applicable performance characteristics such as fluid compatibility, cycle fatigue and stress corrosion for metals and arc tracking, and flammability and odor for non-metals. Links are also available for external materials data sources such as the TPSX database run out of NASA Ames Research Center and some materials handbooks (one of which requires a subscription to access). A link to the NASA Standards Web site is also included.

The next few paragraphs explain how NASA parts and packaging engineers can pursue obtaining a username and password for these valuable resources.

GIDEP Web Site

http://www.gidep.org/

Select Join FREE from the main menu on the left. Under Join FREE, select How To Join; this brings up the GIDEP Membership Requirements page. Click the Application link for the Application for GIDEP Participation.

Take your application to your local GIDEP representative. The NASA Representatives are:

NASA Ames: Andrew Hocker
NASA Dryden: John Relja
NASA GSFC: Mike Sampson (contact Ed Rutkowski)
NASA GRC: Vince Lalli
NASA HQ: Eric Raynor
NASA JSC: Kent Castle
NASA Stennis: Theadore Mason
NASA KSC: Phillip Swihart
NASA LaRC: Duane Pettit
NASA MSFC: Gary Kennedy

If one of these people is not your GIDEP representative and you do not know who your representative is, contact the GIDEP Help Desk (gidep@gidep.corona.navy.mil, or 909.273.4677 from 6:00 a.m. to 5:00 p.m. Pacific Time) to get the name of your company's representative.

Fax the completed and approved (signed) form to 909.273.5200 or via mail to GIDEP Operations Center, P.O. Box 8000, Corona, CA 92878. You will receive notification by e-mail with your username and password.

CALCE Web Site

http://www.calce.umd.edu

The Web Account button is at the top next to the search box. Go to the bottom of the page and select Request for CALCE Member Access. Fill out the online form and be sure to note that you are a participant in the NEPP Program.

MAPTIS-II Web Site

http://maptis.nasa.gov/

In the drill-down menu on the left-hand portion of the site, under the MAPTIS-II Home Menu is a link for Application for Access. This pulls up a printable form that can be filled in by hand (hard copy) and faxed to the number shown at the top of the form. The form requires a manager's name, phone number, and e-mail address, and the requester's signature. The MSFC contact (shown at the top of the form) will issue you a user name and password by e-mail. These are used in the login form that pops up when you click on the link called MAPTIS-II Sign-In.

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Government Electronics and Information Technology Association (GEIA) Overview and January 2004 Committee Meeting Highlights

EIA/GEIA Overview

Most engineers in the electronic parts and packaging field are aware of the Electronic Industries Association (EIA) and its many subsidiary organizations, including the Government Electronics and Information Technology Association (GEIA). GEIA "promotes the interests of the U.S. electronics, communications, and information technology industries, with regard to Government markets, requirements, and technical standards at the Federal, State, and local levels." The GEIA is the home of the G-12 and G-11 Committees for Solid State Devices and Component Parts, respectively. The G-12 Committee "develops solutions to technical problems in the application, standardization, and reliability of solid state devices" and writes EIA standards and specifications to capture the newest best practices and guidelines or recommends changes to the military specifications and standards as applicable. The G-11 Committee does this as well, but it is normally focused on passive part types, while the G-12 Committee almost exclusively examines active parts and packaging issues. Both of these committees fall under the purview of the Systems, Standards, and Technology Council (SSTC), which acts as the technical advisory group to the GEIA Board of Directors and is a forum for discussion of technical management matters, preparing industry positions on proposed legislation, studies, regulations, standards, and related documents. The NASA Electronic Parts and Packaging (NEPP) Program supports NASA's participation in the G-11 and G-12 quarterly meetings normally sending several representatives though they participate as guests of the GEIA because it is an industry association.

Following a month of work on the Web site, the GEIA area is back up and running and can be accessed by going to www.geia.org, pulling down the "Councils & Committees" link on the menu bar, choosing "Systems, Standards, and Technology Council (SSTC)," and then selecting either the G-11 link or the G-12 link. This page shows recent white papers, the schedule for the next two quarterly meetings, prior meeting minutes, and contact information for the chairman. To access the two most recent meeting minutes and agenda information for the G-12 Committee, click on the "Members" icon and enter the following ID and password: G12, EIA5962.

The G-12 meeting, over its 4 days, hosts a number of subcommittee meetings, liaison reviews with the Defense Supply Center Columbus (DSCC) points of contact on electronic parts standards and specifications, and reports from other Government and related organizations such as NASA, the Aerospace Corporation (for their customer the U.S. Air Force Space and Missile Systems Center), the European Space Agency (ESA), the Defense Semiconductor Association, and the Automotive Electronics Council (and many more). The subcommittees cover the following subjects:

- Semiconductors
- Microcircuits
- Radiation Hardness Assurance (RHA) and Characterization
- Hybrids and Multi-chip Modules (MCMs)
- Mechanical Standards
- Quality and Reliability of Solid State Products
- Diodes
- Plastic Encapsulated Microcircuits (PEMs)
- Radio Frequency (RF) and Microwave
- Parametric Control for MIL-PRF-19500 Specifications
- Residual Gas Analysis (RGA)
- Discrete Power Devices Standardization
- Design Guidelines for Satellite Parts
- Coefficient of Thermal Expansion (CTE) Mismatch
- Hybrid Resistance to Soldering Heat
- Glass Strain
- Thermal Transient Impedance Implementation for Junction Field Effect Transistors (JFETs)
- Failure Rate Estimating Methods
- Scanning Acoustic Microscopy Test Methods
- Corona Breakdown
- Lead-Free Issues, Device Marking for Ultra-sensitive Electrostatic Discharge (ESD) Devices
- Derating, MIL-STD-883 Test Method Issues
- Accelerated Burn-in Regression for Glass Power Diodes
- Ball Grid Array (BGA) Standardization.

The G-11 Committee had an operating hiatus in the 1990s but has recently started meeting again. A similar mix of industry and Government organizations is represented at the G-11 meetings, including a NASA presence. The NEPP Program supports this meeting, including the chairmanship of the Capacitors and the Filters and Networks subcommittees. The subcommittee topics include the following topics:

- Capacitors
- Circuit Breakers
- Connectors
- Filters and Networks
- Coils and Transformers
- Fuses and Lightning Arrestors
- Hardware
- Insulators and Insulating Materials
- Oscillators and Crystals
- Relays
- Resistors and Resistance/Capacitance (RC) Networks
- Switches
- Wire and Cable.

January 2004 EIA G-12 Committee Meeting, Phoenix, Arizona

Below are highlight topics from the EIA G-12 Committee Meeting held January 2004 in Phoenix, Arizona. Readers interested in the details of the discussions and issues are encouraged to read the full report online at:

http://nepp.nasa.gov/index_nasa.cfm/477/7F5D12CF-8B1E-45D4-8CE1A1A4490D5E2D/

DSCC (Defense Supply Center Columbus) Audits: DSCC repeated their offer to allow original equipment manufacturers' (OEM) representatives to participate in DSCC audits.

Microsemi Relocation: In the move of Microsemi from Santa Ana, California, to Scottsdale, Arizona, the IPG company is slated to assume Santa Ana's wafer fabrication except for the 1N6638-6643 family, which will go to Lawrence, MA. All modules will go to Lawrence as well over the next 18-24 months.

Temperature Derating of Discretes: Temperature derating of discretes has traditionally contained an error: Leakage current causes heating even at very low power levels, and the curve is no longer linear as it curves away at low power leading to an unappreciated risk of thermal runaway. A proposal was made to define T_{op} as case or ambient temperature, and to use the operating temperature of the device instead of T_j in derating curves.

Updates and Upgrades to SD-18 (Defense Standardization Program Guide for Part Requirements and Application): Funding for updates and upgrades to SD-18 has been approved and is imminent in order to add sections on lessons learned and design guidelines, diminishing manufacturer sources and material shortages (DMSMS), flat panel displays (to be added by AMCOM), and ethylene tetrafluoroethylene (ETFE) wire guidance.

Aerospace Qualified Electronic Component (AQEC) Overview

Corona Test Method Task: This work may be stopped due to lack of participation.

MIL-STD-1580C: The task will look at adding some guidance on which parts should undergo destructive physical analysis (DPA) to this space parts guideline.

Long-Term Storage Task: A review of historical documents was completed. Future work will involve receiving inputs from the NASA White Sands facility.

GIDEP Alert CE9-A-04-02: The parts identified in the recent Government/Industry Data Exchange Program (GIDEP) Alert CE9-A-04-02 are only made and tested in Thailand, though the alert does not make this clear. The Thailand facility is not owned by Texas Instruments; rather, it is owned by a contractor with a U.S. Military Qualified Manufacturers List (QML) V certified line. The problem discussed in the alert is one that has occurred before at that location.

Residual Gas Analysis (RGA) Workshop

Failure Limits: The current test method can allow a 20% failure rate, which is considered unacceptable. Oneida considers 5,000 ppm to be a suitable limit because they see much higher numbers when a part fails (15,000+ ppm). Oneida recommends a process monitor; Telcordia requires an 11/0 Accept/Reject plan at 5,000 ppm.

RGA Results: An experiment by Pernicka Corporation revealed parts that have moisture close to 5,000 ppm, high oxygen content, and a 20:1 oxygen/argon ratio, and no helium or fluorocarbons, but the extracted gas volume was high. The root cause was found to be a defective seam sealer that provided an occasionally lower-than-optimum pressure that allowed minute blow-out between the nickel plating and the base metal. This leak is stress sensitive, and it is suspected that helium bombing pressure squeezed it shut, hence the <100 ppm helium. In the discussion above, the specification is written such that "no helium" means <100 ppm. One Pernicka recommendation is to have all values recorded to assist in diagnosis.

DSCC Package Testing: Package sizes 0.1 cc, 1.0 cc, and 0.01 cc are being built with moisture intentionally sealed inside to help develop the test method for small packages. The package manufacturing is in progress.

JEDEC 13.2 Subcommittee Meeting

M38535 Testing: A major U.S. Air Force contractor is requiring that their internal and subcontractor procurements require full M38535 testing for their microcircuits procured for space flight applications, as they are not secure with test optimization.

MCM and Hybrid Definitions: Currently there are a few hybrids QMLed under M38535 and some multi-chip modules under M38534. There are considerable differences between the specifications; 38535 generally is considered more rigorous than 38534. DSCC uses the rule that parts containing only chips from the same Federal Supply Class (FSC) (5962 for microcircuits, including hybrids) are considered multi-chip modules and come under 38535, and parts containing devices from multiple FSCs are considered hybrids covered by 38534.

Test Optimization: Rules for handling M883 compliancy and M883 Class Q were discussed. Extensive changes have been made to MIL-STD-883 Draft Revision F. DSCC has provided a very good summary of the changes that should make change review much more efficient. The discussion of test optimization shows that most people understand what is needed to operate test optimization responsibly; however, there is no single consistent approach.

There is a JEDEC Guidelines document, JEP121, for optimization, and it is referenced in 38535. The 38535 is referenced in a note in paragraph 3.1. It does not appear that JEP121 is actually being used by any party in the process.

TM2018: For Test Method 2018, the changes proposed through Task Group 2001-2002 were accepted unanimously by the Task Group, and JC-13.2 voted to pass the change request forward to DSCC.

Wire Criteria: Regarding criteria for crossing wires, advanced packages with high pin counts, especially multi-tier styles, may not meet current criteria that were relevant to older packages years ago. Aeroflex proposed changes to meet their needs some time ago. NASA and The Aerospace Corporation have provided input for modifications and a request for more information. The JC-13.2 committee agreed to pursue development of improved language for MIL-STD-883.

Hermeticity: There is optimism that progress is being made based on Pernicka's presentation during the RGA workshop. NASA asked whether optical leak testing works for UA and UB style packages. Experience in the13.2 committee is that it does not, but the equipment manufacturer claims that it does. Samples need to be provided for an evaluation.

G-12 Space Parts Subcommittee Meeting

NGS: The U.S. Air Force (AF) Space and Missile Systems Center (SMC) needs improved standards for such things as parts management. They would prefer to use an NGS such as AIAA-R-100, but one that is stronger and more robust

MIL-STD-883 TM 1019/ELDRS: DSCC cited that for MIL-STD-883 Test Method 1019, enhanced low-dose rate sensitivity (ELDRS), requirements are still being discussed, but it has been decided to test parts to current requirements. New part number extensions to cover ELDRS were proposed.

National Semiconductor discussed the extensive testing at Navy Crane to try to understand the fundamentals behind ELDRS. ASTM 1892 provides copious information on ELDRS, as well as guidelines. The JC-10 committee is working on terms and definitions pertaining to radiation hardness and testing. Accelerated methods for ELDRS are being investigated while the unaccelerated test is still needed for accurate characterization.

European Space Agency (ESA) Updates: ESA stated that the ECSS-Q60-01 ESA Preferred Parts List has been issued. The derating and end-of-life document, ECSS-Q60-12, is ready for imminent release. ECSS documents and parts stock information are available through the ESCIES Web site.

ESA is working to develop a second source for MOSFETs (other than International Rectifier).

ESA has sent out a questionnaire on the topic of lead-free alloys to European suppliers to determine what they plan to do. ESA is exempt from the European legal activities and so does not have to go lead-free, but like NASA, they anticipate having to use lead-free parts and assemblies.

Galileosat (a large global positioning system [GPS]), ESA's largest-ever project, has established rules to prevent EEE parts from export restrictions and other impediments to supply. ESA is trying to avoid International Traffic in Arms Regulations (ITAR) restrictions.

Upcoming Meetings

The next G12 meeting will be in Portland, ME, May 17-21, 2004. The next JC-22 committee meeting will be held April 20-22, 2004, at the Joint Electron Device Engineering Council (JEDEC) Headquarters in Arlington, Virginia. The Institute for Printed Circuits (IPC)/JEDEC Conference on Lead-Free will be held March 17-19, 2004, at the Marriott Hotel in San Jose, California. ESSCON, which should have occurred in Lisbon this year, has encountered difficulties and will be postponed to 2005.

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DEPARTMENTS

WebEx News

NEPP's Knowledge Sharing Program fosters and provides venues for knowledge transfer among project parts engineers, component engineers, designers, and project managers. Its goal is to ensure NASA mission success by interfacing with industry and academic partners to provide new information and to collaborate with commodity experts. The WebEx conference series is one of the Program's products, along with this newsletter *EEE Links*, the http://nepp.nasa.gov Web site, and training materials.

A programmatic goal is to present a WebEx conference once per month. Presenters who can talk about recent test results or other technical findings that are important to NASA engineers are sought, though presentations may also be offered that provide insight into NEPP programmatic activity and its strategic partnerships. The format consists of a slide presentation with audio via a telephone connection. A moderator is present to communicate logistical concerns or relevant questions to the presenter, during the presentation, which may be communicated by the audience members through a chat tool. At the end of the presentation, the audio is opened by a telephone operator in order to take questions directly from the audience members. The session is ended with a very short evaluation form, which enables the NEPP staff to receive feedback and statistics on attendance. The presentation is planned for 1 hour including the question-and-answer period, which can be joined or left transparently by an attendee. Past and future NEPP WebEx topics can be found at http://nepp.nasa.gov/index_nasa.cfm/978/ (scroll down once this page has been accessed to see the list) or by clicking on the "Knowledge Sharing Program" link, which is the very first on the left-hand menu bar on the NEPP home page (http://nepp.nasa.gov).

The most recently completed NEPP WebEx was presented by Dr. Reza Ghaffarian of NASA JPL on the topic of qualification testing of BGA interconnect assemblies for space use. Dr. Ghaffarian covered many aspects of the technology, including the different area geometries and materials and the tests that can be used to show that an assembly has been designed and assembled in a manner that will endure space travel. Dr. Ghaffarian's points support that BGA interconnect reliability has great dependence on the assembly in which it is used. A package that has been "qualified" in one system may not be sufficient in a different system that has a different board configuration and environmental profile. At its root, this concept is broadly applicable to all space parts. Dr. Ghaffarian used several IPC test methods in this work which are: IPC9701 (temperature cycling), IPC9702 (bend test), IPC9703 (mechanical shock), and IPC9704 (mechanical shock and vibration). IPC7095 is an overall assembly process guideline. Go to http://standards.nasa.gov to find these documents.

The next NEPP WebEx will take place on February 24, 2004, at 2:00 EST and will be presented by Mr. Jim Blanche from NASA MSFC on the topic of Study of Lead-Free Alloys for Use in Electronics. Mr. Blanche is involved with work in the electronic packaging field at NASA MSFC and work being done by for NASA through the CAVE consortium at Auburn University. He will also introduce the JCAA/JG-PP Joint Group for Pollution Prevention working group activities on lead-free, which is supported by NASA, DOD, and many aerospace and military industry contractors.

Mr. Jim Blanche has been working in electronic packaging at NASA MSFC for 45 years, finishing his time as a civil servant as the Group Leader of the Electronic Parts and Packaging Group in the Avionics Department. He has been a member of the NASA Workmanship Standards Technical Committee since 1983 and was involved in the writing of all of the MSFC and NASA electrical workmanship standards for soldering, crimping and wire wrap, conformal coating and staking, cabling and harnessing, printed wiring board design and fabrication, and ESD control. He has published extensively on BGA technology as well and has provided his expertise to industry consortia on BGA reliability. Mr. Blanche is now an employee of Allied Aerospace and is stationed with the MSFC EEE Parts and Packaging Group.

To enroll in this conference, please register online at http://nepp.nasa.gov/wx/ by February 22, 2004. WebEx allows you to join presentations at meetings or conferences from your PC at your work site. You can pose questions to presenters and participants using the chat capability. In order to participate, you will need Internet connectivity at your computer and preferably a telephone with speaker, mute, and teleconference capabilities, as well as the completed registration form (http://nepp.nasa.gov/wx/). **Note:** Macintosh users may have to follow additional steps; these instructions will be provided well in advance of the event. If you are a Mac user, please indicate this on the registration form.

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FEATURE CONTENT

Expert Interview With Ken LaBel: Overview of NEPP FY04 BOK/TRO Tasks

EEE Links interviewed Ken LaBel to gain insight into the way the NASA Electronic Parts and Packaging (NEPP) Program is currently run and the nature of NEPP's upcoming FY04 tasks. Ken is the Radiation Effects and Analysis Leader for Code 561, and he manages several NEPP radiation tasks. He is also acting as one of the program's interim managers who coordinates tasks and evaluates work performed. (Go to http://nepp.nasa.gov/index_nasa.cfm/477/1E330F3C-42EE-4399-ACEF90F749079D3C/ to access Ken LaBel's publications on the NEPP Web site, or contact him via e-mail at Kenneth.A.Label.1@gsfc.nasa.gov.)

EEE Links: What is the overall focus of the NEPP Program this year?

Ken LaBel: The NEPP Program has come full circle in some aspects. Ten years ago, NASA's EEE parts program was focused on near-term reliability. Then in the mid to late 1990s, NEPP became more of a technology-based evaluation program, so near-term missions were not being funded sufficiently and not much work was being done in those areas. The highlight was what would be relevant within a 10-year span rather than a 2-year timeframe. After NEPP migrated from NASA HQ Code AE to NASA HQ Code Q in spring 2003, a decision was made to return to the near-term scope to provide broad-scale solutions over a period spanning the next 3 years. This approach was brought about in part because of NASA HQ's current emphasis on wide-ranging technology needs and applications, and also on general-purpose work rather than niche work.

The task focus for this year is on two things: 1) near-term issues, and 2) a study phase with Body of Knowledge (BOK) tasks to determine what we know about various technologies, their state of technology readiness, and their reliability and radiation effects. Then we will work to identify gaps in terms of whether a given technology needs more work in order to become a real product. Before, proposals were generated simply to evaluate technologies, whereas now we have to state what we know about the technologies and what others are doing with them (e.g., reliability and evaluation), and propose a plan of action based on knowledge gaps that have not been addressed otherwise. This is a more formal structure for what we have been doing all along, but at a much more broad-brush level. These BOK tasks are delivery oriented, providing the customers (designers, program managers, parts engineers, etc.) with documents containing technical information they can use for space missions. These will be living documents that will be updated as new information becomes known on given technologies.

In the past couple of years, there has been a perception that the NEPP Program seems to have become centered upon NASA GSFC and NASA JPL, which does not uphold the One NASA initiative. The objective is not just to spread the money from Center to Center, but rather to include work from all the Centers. Toward this end, we're bringing in NASA MSFC's reliability work and NASA JSC's work in large systems (stations and shuttles).

There is some focused research slated for FY04 as well as the BOK tasks, but these tasks are mostly continuations from FY03; from the radiation side, these are tasks co-funded by DOD and other agencies. There are fewer research tasks in general, but the ongoing ones show the widespread nature of NEPP's work and the collaborations involved (e.g., DOD, universities). There is a larger push to be cost effective by partnering with universities; Vanderbilt University's work with radiation effects is a good example. The actual tasks are yet to be determined, as the graduate students will devise the best plan based on the roadmap for all of NEPP.

EEE Links: Where will the BOK documents be housed, and who will be in charge of distributing the information?

Ken LaBel: How we are going to spread the word on these documents is still under discussion. One positive outcome from the NEPP Program reorganization is that there will be a designated single point of contact (POC) to represent each NASA Center (Mike Sampson at NASA GSFC, Chuck Barnes at NASA JPL, Geoffrey Yoder at NASA JSC, Mark Strickland at NASA MSFC, James Bockman at NASA LaRC, and Vince Lalli at NASA Glenn Research Center). We're treating this approach more like a steering committee than just a group of POCs, so each Center has a person responsible for both distributing information to their Center and gathering information from their Center. The NEPP Web site will be the repository for the information, but how we distribute it beyond that is yet to be determined.

To achieve NEPP goals at all of the Centers, we need to hold weekly teleconferences, as these are a good venue for sharing technical information among the Centers. We need to do this at a programmatic level to ensure open and timely communication, all Centers being on the same page, and sharing lessons learned and technical information. The steering committee involves ongoing teleconferences to determine priorities for tasks, and also to determine budgetary constraints.

EEE Links: Who runs NEPP (from the NASA HQ level and at the NASA Center level)?

Ken LaBel: NEPP Program leadership was transferred from NASA HQ Code AE to NASA HQ Code Q in spring 2003. Tom Whitmeyer was at the time in Code Q; Tom is now managing another program but is still acting manager for NEPP. Code Q is seeking a replacement to manage NEPP at the HQ level. Tom has delegated technical work to Mike Sampson and me; Mike's task management focus is on reliability, passive components, and packaging, while mine is on radiation and active components. Sometime soon, Code Q is expected to issue a letter formalizing roles and responsibilities not only of Mike and myself, but also of POCs and task managers for all the Centers. Mike and I are now acting interim managers who coordinate NEPP tasks and evaluate work performed.

EEE Links: Who are NEPP's customers?

Ken LaBel: NEPP's primary customers are flight projects, all the NASA Centers, and technology developers in industry and at NASA. Our job is to help our customers deliver reliable, radiation-tolerant products.

EEE Links: Who performs the work of NEPP?

Ken LaBel: Mostly the NASA Centers (both civil servants and contractors) do the work of NEPP, but some work is farmed out to universities when it is cost effective.

EEE Links: How do the NEPP products reach their customers?

Ken LaBel: The NEPP Web site is the main vehicle for product dissemination, but conferences are another venue. The NEPP Annual Conference is one example, and there is current discussion about setting up industrial exhibit booths at other conferences where we can display our products to the community. We can bring sample documents to these events as products.

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Defining the Body of Knowledge (BOK) and Technology Readiness Overview (TRO) Concept

An emphasis has been identified for 2004 for the NEPP Program to capture in Body of Knowledge (BOK) and Technology Readiness Overview (TRO) works, the state of the art of important existing and new technologies being used or that may be enabling in NASA spacecraft. The BOK and TRO tasks span each of the three NEPP technology project areas: parts, packaging, and radiation effects. The summaries below describe each of these BOK or TRO tasks including points of contact at the cognizant NASA Center.

BOK and TRO studies are reports that capture industry and NASA knowledge about the technology area and the best practices that we've learned through prior testing and use. BOKs will support the TROs, which provide concrete instructions for users. TROs are brief overviews that provide information about what to be aware of when considering using a particular technology. These overviews include information such as a description of the technology, status of available technology, lessons learned, recommendations, issues and concerns (e.g., reliability, radiation), qualification guidelines, activities, produceability and manufacturability, applicability to NASA and aerospace missions, and timetables for readiness. On the home page of the NEPP Web site, you can select the Technology Readiness Overview link and choose from a list of completed TROs.

A BOK document first establishes the scope of the technology with respect to its importance and use in NASA hardware. It then focuses on providing brief guidance (in five to 10 pages) on that technology or technology issue. BOK documents are intended to provide, where applicable:

- An overview of the technology including test methods, assembly methods, reliability issues, and application guidelines.

- An overview of the technology's applicability to space and aeronautics: 1) Where has the technology been applied (commercial, space, military)? 2) Where can the technology be applied? Has it been identified within NASA roadmaps as a need? This may include a survey of NASA flight and research areas at the enterprise level, for applicability.
- An overview of the technology's maturity, produceability, and commercial availability.
- A summary of reliability and quality knowledge for the technology: 1) Under what conditions has long-term testing been done, and what were the results? 2) Is this part made often enough and in large enough lots to demonstrate a repeatable manufacturing process? 3) Has representative product been tested for suitability for space use? 4) What are the short, mid-term, and long-term failure modes? 5) What gaps still exist in our knowledge about the technology's applicability in space? 6) What are some risk mitigation approaches that can be used with this technology?
- Discussion of the technology's evolutionary path to examine if future, expected changes will change the applicability of the part (e.g., will the "Radiation X" problem increase or decrease as CMOS technology evolves?).
- Identification of experts, technology sources, and test houses, etc., inside and outside of NASA and the U.S., with links and points of contact where possible.
- Facilities within NASA, within the U.S. (Government, university, industry), and outside the U.S. who are working with this technology.
- Recommendation for follow-on NEPP task (if applicable).

To access task descriptions on the NEPP Web site (http://nepp.nasa.gov), choose the Publications link in the left menu on the home page, and then select Tasks Search from the left menu. If you click the Search Tasks button, or select Search Tasks-All from the left menu, all tasks housed on the NEPP site will display (grouped under parts, packaging, and radiation in a scroll-down list).

You can also break your task search down by project by choosing Search Tasks Per Project from the left menu in the areas of parts, packaging, and radiation. The same search results also can be achieved for each of these three areas from the home page: Choose parts, packaging, or radiation from the left menu on the home page, and select tasks from the subsequent left menu (e.g., Home>Parts>Parts Tasks, Home>Packaging>Packaging Tasks, Home>Radiation>Radiation Tasks).

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Summary of All Fiscal Year 2004 NEPP Tasks

As discussed above, the NEPP Program is accomplished through a collection of tasks that are led by specialists and technical managers around the Agency. Most of the tasks to be accomplished in

Fiscal Year 2004 are technology readiness overview (TRO) or body of knowledge (BOK) tasks. Others are specific to certain technology needs or issues or support important ongoing work needed to support the Agency's EEE parts organizational needs. There are 66 tasks defined for Fiscal Year 2004. Each is summarized briefly below, and the point of contact is noted.

Traditional Parts Coordination
POC: Michael Sampson, NASA GSFC

Task Description: Traditionally, NASA has relied heavily upon the U.S. Military (MIL) specification system for its EEE parts needs. In recent years, NASA has made more extensive use of non-MIL parts in order to get the benefits of increased functionality with smaller size and weight. A healthy MIL system is still one of NASA's best opportunities for obtaining reliable components for flight hardware. Similarly, an understanding of industry specification activities is essential to successful incorporation of commercial parts in flight hardware. The purpose of this task is to provide technical and programmatic support to ensuring that NASA's interests are addressed in ongoing and future MIL and industry specification changes.

Benefit to NASA: NASA's active participation in MIL and industry specification activities will ensure that reliability is not sacrificed in the interest of cost reduction alone. Routine involvement will help retain/develop NASA expertise in EEE part commodity specific areas.

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Institute for Space and Defense Electronics (ISDE): Vanderbilt University
POC: Ken LaBel, NASA GSFC

Task Description: ISDE is the recognized academic leader in support of radiation hardening and radiation effects research. The majority of ISDE's funding is from DOD, but the work is applicable to NASA missions and needs. With a relatively small investment, NASA can access a wide base of technical capabilities and define specific tasks for NASA needs.

Benefit to NASA: Key benefits include the ability to tap into an acknowledged base of expertise for a minimal cost while providing funding for students who become available to the aerospace community.

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Radiation Coordination
POC: Ken LaBel, NASA GSFC

Task Description: This task is focused on coordinating radiation effects efforts at the three prime centers involved (GSFC, JPL, JSC) as well as ensuring that requirements from other NASA centers (GRC, MSRC, LaRC, KSC) are being met. This includes attendance and participation at conferences, technical interchange meetings, technology reviews, etc. in order to stay abreast of the radiation effects/aerospace community developments. Coordination of databases is also a prime consideration.

Benefit to NASA: Two main benefits are continuing the push toward One NASA and continued ties into other organizations in the radiation effects community to minimize duplication of efforts.

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NASA Parts Selection List (NPSL) Maintenance and New Development
POC: Michael Sampson, NASA GSFC

Task Description: The NASA Parts Selection List (NPSL) provides NASA Projects with EEE part selection and application guidelines. Since 1998 this Web resource has served as a repository for NASA's corporate knowledge on reliable EEE part technologies for space flight use. Changes in availability of existing technologies, and the development of new technologies suitable for flight use, necessitate periodic maintenance of the NPSL in order to remain current. In addition, several EEE part commodities are not currently addressed within the NPSL. Through this task, existing sections of the NPSL will be maintained and new sections added as appropriate for NASA's needs. In addition, an effort will be completed to produce an abridged version of the NPSL that is suitable for printing.

Benefit to NASA: The NPSL is one of NASA's most referenced resources for EEE parts selection and application guidance. Extension of the listing to include commodity types not previously referenced will further the value of this resource as a "one-stop" reference tool for NASA designers and parts engineers. Development of a printable version will expand both the use and usefulness of this tool.

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Information Management and Dissemination Project
POC: Darryl Lakins, NASA GSFC

Task Description: The Information Management and Dissemination (IMD) Project's primary objective is to methodically disseminate the information that is generated and collected by the NASA EEE Parts/Packaging/Radiation Effects engineers and to coordinate task reporting. It provides essential information regarding the reliability, performance, availability, application, and cost of electronic parts and packaging technologies through a World Wide Web interface. It is responsible for the performance, security, operation, maintenance, and upgrade of the hardware/software platform, and enrichment of the content through partnerships with external entities in the private, academic, and Government sectors. Its customers are NASA specialist researchers, project engineers and scientists, and program managers.

Benefit to NASA: The benefit the IMD Project brings to the Agency is ready access to NEPP research products, enriched by content from academic, Government, and industry partners, from a single point of entry, reducing risk and lowering research costs at the project level.

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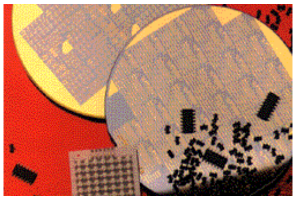
COTS PEMs: Body of Knowledge on COTS Insertion Experience Interagency Information Exchange
POC: Chuck Barnes, NASA JPL



Task Description: The ability to insert COTS microelectronics into NASA systems with minimum risk is critical to the continuing success of NASA missions from the perspective of increasing performance, compact design, lighter weight, and minimum power consumption. However, the challenge of minimizing risk can be very difficult, especially for systems that must function in extreme environments for long periods of time, such as a mission to the Jovian system. Other systems, such as the International Space Station (ISS) and the Shuttle, are more amenable to COTS insertion. Thus, there are a wide variety of scenarios in which COTS microelectronics can play a role in NASA engineering systems and instruments. The purpose of this task is to facilitate, in a proactive manner, COTS insertion throughout NASA by providing continually updated surveys, reviews, analyses, and information on how NASA projects at the Centers are accomplishing COTS insertion, and how other agencies, the private sector, and academia are dealing with the issue of COTS usage in high-reliability systems. Critical to the success of the task will be setting up an appropriate and effective Web-based information exchange on the NEPP Web site that responds to communication interfaces set up with a variety of entities. Fortunately, many of these exist already, and we will be able to build upon existing structures such as the NASA Electronic Parts Assurance Group (NEPAG).

Benefit to NASA: Low-risk insertion of COTS microelectronics in NASA flight project engineering systems and instruments will be of great benefit for enhancing performance and reducing weight, volume, and power consumption. It will also allow the selection of a wider variety of part types and features. These advantages have led to a variety of techniques for minimizing the risk of COTS insertion at the NASA Centers. These techniques vary because of the large differences in mission performance and environmental requirements. It is not at all clear that all users within NASA are aware of the nature and variety of these insertion techniques at all the NASA Centers. In addition, other high-reliability applications outside of NASA, including the U.S. Department of Defense (DOD) and the automotive industry, have developed their own techniques. This task will help to ensure that this knowledge is known and available across NASA.

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Auburn's Center for Advanced Vehicle Electronics (CAVE)
POC: Mark Strickland, NASA MSFC

Task Description: This task provides access to the CAVE research programs by NEPP. The task pays for the yearly subscription and allows the CAVE organization to assign a point of contact to NASA and a means for NASA to influence ongoing research.

Benefit to NASA: The CAVE consortium provides a solution for accumulating reliability data on newly available electronics in a cost-effective manner. CAVE provides a readily available test bed for NASA use.

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Hardened-by-Design Microelectronics: Comparison and Test Methods
POC: Jim Howard, NASA GSFC

Task Description: Hardened-by-design (HBD) techniques are a proposed way to reliably infuse COTS-style (and hopefully, near state-of-the-art) microelectronics technologies into space systems. Multiple agencies (DTRA, AFRL) have funded work in this area in FY03. DARPA has now entered the picture with an $11M Broad Agency Announcement for new technique development, as well as a $2M NASA Research Announcement from NASA Code R for low-power HBD microelectronics. Discussions are in place for NASA to provide the independent technology assessment for DARPA/AF/DTRA HBD since infrastructure has already been developed at NASA. This task will complete the work begun in FY03 on 8051 test vehicles, will provide documentation on current HBD techniques/availability, and will support FY04 evaluation of new HBD design techniques.

Benefit to NASA: With the lack of foundries producing radiation-hard semiconductor devices (and difficulties in yield for some that are producing radiation-hard product), HBD is likely a key part of the future for hardened space systems. This effort will provide NASA with guidance for selecting and using HBD techniques in a risk-averse manner.

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Radiation Effects and Transformational Communications
POC: Steve Buchner, NASA GSFC

Task Description: NASA, in partnership with many other agencies such as NRO, DARPA, AF, and MILSATCOM, has begun formulating common transformational communications architecture (TCA). TCA is essentially a space-to-ground communication system that operates much like the Internet with TCP/IP protocols. Many new technologies that are foreign to space use are expected in these systems. This task focuses on identifying those technologies, assessing the status of the technologies, gaining radiation information/knowledge, and providing recommended approaches for further testing or system approaches.

Benefit to NASA: Many of the technologies being discussed have no space history or qualification; documented risk and risk reduction strategies are the prime benefit.

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Board-Level Radiation Qualification
POC: Geoff Yoder, NASA JSC

Task Description: Many NASA projects are trying to provide a more cost-effective means of doing business. One concept is the use of COTS-populated printed circuit boards (PCBs). Programs such as ISS, due to the volume of electronics, have little choice. While the use of board-level radiation qualification may not be appropriate for all NASA missions, this effort will identify the radiation-related strengths and weaknesses to this approach and identify and work to provide improved test options. This will be done by a combination of literature surveys, directed technology modeling, and test facility usability for board-specific issues.

Benefit to NASA: Cost benefits of irradiation at system/board level are clear; however, there is still much controversy in the radiation effects community over the approach, re-use of data, adequacy of testing, proton-simulation of heavy ions, etc. It is also clear that there is a risk reduction from this approach, but quantitatively defining the reduction has been difficult. This task aims to address the issue as One NASA and to define appropriateness of proton SEE screening in lieu of heavy ions.

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Radiation Screening of Modern Packaged ICs
POC: Gary Swift, NASA JPL

Task Description: Modern integrated circuits (ICs) often present challenges for defining appropriate radiation testing parameters due to complexities involved with device packaging. Issues include die (sensitive volume) access and/or particle range for heavy ion single event testing, impact of the package on total ionizing dose (TID) characteristics, PEMs/coating effects on linear devices, and device thinning, etc. This task is focused on defining the current state of knowledge, providing recommendations for qualification, and issuing a direction for future work in these areas.

Benefit to NASA: There are many unknowns for radiation qualification of modern ICs. The benefit of this task is that it defines the unknowns and addresses the issues that quantify risk for flight projects, as well as point to viable approaches in increasing system performance reliability.

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Statistical Sample Size for Radiation Effects Qualification
POC: Ray Ladbury, NASA GSFC

Task Description: With an increasing number of COTS devices being used in large numbers in space systems (sometimes as many as 10,000 of one active component is in a system; sometimes a single unit is used), the issue of what constitutes as a sufficient number of test samples to qualify a COTS device becomes important. A flight anomaly occurred on the Hubble Space Telescope (HST) in which the sample size was 3 and the flight quantity was 1,440. Further testing on 100 additional samples proved to find low-probability events. This issue is expected to be prevalent with COTS. In this task, statistical methods and data searches will be used to develop guidance for NASA flight projects.

Benefit to NASA: The chief benefit is in reduction of unexpected anomalies in space, which will increase system reliability.

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Technology Programs Collaboration: Radiation

POC: Ken LaBel, NASA GSFC

Task Description: Other programs within NASA (Code S, ESTO, Code R, etc.), DoD (DARPA, DTRA, AFRL), and industry are investing technology development funds in an effort to mature new hardened microelectronics. As these technologies are being developed, independent assessment of radiation characteristics is often sought. NASA (NEPP) has filled this role in the past and will continue to do so in FY04.

Benefit to NASA: There is a huge leverage for NASA when considering the millions of technology dollars that DOD and others are investing. Spending a few hundred thousand dollars versus the millions invested previously allows NASA to partner for a relatively low cost.

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Analog Single-Event Transients – ASET

POC: Christian Poivey, NASA GSFC

Task Description: Commercially available linear bipolar and CMOS devices are often susceptible to single energetic particle induced transients. Past NEPP efforts were focused on developing appropriate ground-based radiation test methods and supporting DoD-funded modeling efforts to determine improved device ASET tolerance. In FY04, this task will:

- Survey existing datasets to classify COTS device tolerance and develop a guideline for what designers can expect from devices.
- Provide radiation effects testing for inputs to DoD-funded models as appropriate.

Benefit to NASA: The key benefit is providing NASA designers with critical information to build more reliable systems, i.e., identifying proper choice of linear devices/technologies and/or inputs for mitigation methods. The objective is to avoid flight anomalies such as those seen on MAP and Cassini. NASA provides key research to the DoD research efforts by its unique use of laser and heavy ion tests.

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Digital Single-Event Transients – DSET

POC: Christian Poivey, NASA GSFC

Task Description: Deep submicron CMOS technology is now moving to the feature size and speed (>1 GHz) regime at which transients induced by a single particle can propagate to storage elements (i.e., a spike causing a bit flip). Technology models used in engineering tools like CREME96 are based on only direct particle hits to storage elements. This task will survey test techniques for digital devices, determine whether existing test methods are adequate for identifying this issue, identify potential impacts of these DSETs to NASA systems, and provide recommendation for efforts required to update CMOS models for predictive tools as well as test techniques.

Benefit to NASA: The key benefit is to understand the adequacy and/or limitations of existing test methods and radiation tools. It is expected that these tools/methods will provide an answer that is under-predicting actual issues, thus compromising mission reliability. Improved qualification tools will allow safer utilization of digital COTS in NASA missions.

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Radiation Impact of Nuclear Propulsion on NASA Missions
POC: Mike Xapsos, NASA GSFC

Task Description: With a major development and planning effort beginning at NASA for utilizing nuclear propulsion on long-life NASA missions, one of the driving factors (beyond safety concerns) will be the radiation exposure created for microelectronics. This task is aimed toward providing a first look at the impact (by first-order location and shielding levels) at electronic systems, as well as defining deficiencies that exist in current technology models for degradation of their performance.

Benefit to NASA: Knowledge and limitations defined for using microelectronics with nuclear propulsion systems will improve reliability and performance of NASA missions.

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Tin Whisker Mitigation Strategy Assessment
POC: Jay Brusse, NASA GSFC

Task Description: Extensive research has been conducted on fundamental growth mechanisms of tin whiskers with no consensus model to explain why whiskers may/may not form on some tin-plated surfaces. Accelerated test methods to judge whisker propensity also do not exist. Without a model and/or tests, end users of tin-plated hardware are left to implement their own whisker mitigation strategies. This task will review the technical literature on whisker mitigation strategies and identify strengths, weaknesses, and limitations of each. Recommendations will be made regarding additional analyses necessary to improve confidence in the long-term effectiveness of each strategy. Through this task, NEPAG/NEPP will continue to participate and leverage off of its long-standing partnership with whisker risk and mitigation consortia sponsored by Computer Aided Life Cycle Engineering (CALCE), NEMI, and JG-PP.

Benefit to NASA: International legislation to prohibit lead in electronic components will increase NASA's exposure to pure tin-plated items that were previously available with an alloy tin-lead finish. Through this task, NASA projects will be provided technical guidance regarding recommendations for mitigation strategies against tin whiskers.

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Alternate Approaches for Component-Level Testing
POC: Ashok Sharma, NASA GSFC

Task Description: Traditionally, NASA projects have assured the reliability of electrical, electronic, and electromechanical (EEE) parts through intensive screening and qualification test protocols performed at the component level. Opportunities for cost and/or schedule reduction without sacrificing reliability may be realized through streamlined test flows or evaluation techniques differing from NASA's traditional tactics (e.g., reduced burn-ins, thermal cycle assessment, switching tests, assembly-level testing, etc.).

Through this task, a survey will be conducted to identify industry and other practices for assuring component-level reliability that may be adapted for NASA's application needs. Similarly, a survey of NASA programs will be conducted to determine typical application environments and stresses. Some preliminary assessment of NASA's applications versus industry component assurance practices will be performed. Recommendations will be made for more detailed assessments of practices that show potential to meet NASA's needs.

Benefit to NASA: Significant benefits will be in improved component reliability, more effective screening and qualification practices targeted for the end-use application environment, cost reduction, and schedule reduction.

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PWB Rework
POC: David Gerke, NASA JPL

Task Description: The use of large, high-density interconnect packages, such as BGAs and high I/O QFPs, have increased in NASA hardware in recent years, as well as the use of large numbers of passive components. Boards built with these packages are expensive and often require rework to replace failed component(s). Industry assembles high volumes of high-reliability printed wiring boards (PWBs) and has numerous methods of accomplishing the rework process. Ideally, a good rework process should have a similar time-temperature profile as that used for the original production solder reflow process. A survey will be conducted to document the various rework methods used by industry and NASA. The reliability assessment work started in FY03 will be continued.

Benefit to NASA: Properly performed rework will reduce the risk of component or board failure, resulting in a reduced risk to NASA missions. Cost reduction will also be realized with a properly performed rework process, as entire assemblies can be placed into service when a single costly component can be removed and replaced reliably rather than discarding an entire assembly when a poor procedure is performed.

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NDE, NDI: Body of Knowledge and NASA Equipment Survey
POC: David Mih, NASA JPL

Task Description: The following work will be performed for this task:

- Survey advanced non-traditional non-destructive evaluation (NDE) inspection technologies (excluding C-SAM) for EEE parts and packaging and report findings.
- Compile all current and standard NDE methods and their effectiveness for examining EEE components.
- Compile an Agency-wide list of existing NDE equipment (excluding C-SAM equipment) available at each of the 10 NASA Centers, which can be utilized for EEE screening processes.
- Survey current real-time X-ray technology and its derivatives.
- Construct a feasibility and trade-off report for the inspection of EEE parts and packaging by various X-ray methods.

Benefit to NASA: The advanced NDE survey reports can be used as a reference tool for unique inspection requirement of EEE parts and packaging. The NASA NDE equipment list can be utilized as an Agency-wide inspection and screening laboratory reference guide. The real-time X-ray report provides a guideline where internal structural images are required to qualify EEE component reliability.

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Extreme Environments: Cold/Hot Temperature Reliability
POC: Reza Ghaffarian, NASA JPL

Task Description: Design guidance will be developed for conventional leaded and newly available packages, as well as bare dies, for use in extreme cold environments. Test results will be compared to the data acquired in the conventional thermal environmental regime through leveraging test vehicles built by the NASA JPL lead consortium and those funded by the Mars Project under thermal cycling resistance electronics (TCRE). When additional funding becomes available, long-term cold reliability requirements also will be addressed. GRC teams will address both cold and hot radiation aspects, and GSFC will address radiation aspects.

Benefit to NASA: Projects involving space telescopes, the Space Shuttle, Mars, asteroids, etc. will benefit from this work. Extreme temperature test could also be used as a screen tool for all mission electronics when their limitations are defined.

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Package-Level Testing: Alternate Approaches
POC: Reza Ghaffarian, NASA JPL

Task Description: This task will develop innovative packaging assessment and qualification methods that will allow rapid, low-risk insertion of existing electronics, newly available COTS, and advanced technologies into NASA systems. It will also develop screening techniques, e.g., use of Moire interferometry with mechanical/thermal combined with virtual qualification. These techniques will be applied to reworked and replaced hardware to induce minimum damage when time is critical, e.g., near launch. Another aspect is data extrapolation using probability, pattern recognition, and neural network.

Benefit to NASA: For all NASA missions, reducing risk, cost, and time for qualification of rapidly changing electronics can be achieved using non-conventional and innovative qualification approaches.

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Board-Level Bare PWB and Board-Level Populated PWB Reliability Standards
POC: Anthony Wong, NASA JSC

Task Description: The following work will be performed for this task:

- Review available standards, and determine applicable printed wiring board (PWB) qualification and screening standards for space avionics.

- Identify approaches to determine bare board and populated board reliability.
- Develop written guidelines for PWB procurement based on qualification standards and reliability requirements.
- Develop PWB manufacturer qualification profile (MQP) criteria best suitable for NASA use.
- Subscribe to IPC D-36 PCQR2 database, which collects and disseminates PWB suppliers' manufacturability data, and from which each flight project can choose the manufacturer best suited for its requirements.

Benefit to NASA: The results will allow NASA to adopt more up-to-date commercial PWB qualification standards for space use. Efficiency will be improved during the PWB procurement process, and improved relationships will be encouraged between the Agency and qualified PWB manufacturers.

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EEE Obsolescence (ISS, SSP, OSP)
POC: Geoff Yoder, NASA JSC

Task Description: Diminishing manufacturing sources and material shortages (DMSMS) is defined as the loss, or impending loss, of manufacturers or suppliers of items or a shortage of raw materials. It is possible for DMSMS to occur at any phase of a program/project—from design and development through post-production. DMSMS has the potential to critically impact space vehicle supportability and manufacturing life cycle. The majority of DMSMS has occurred in the electronics areas (microcircuits) but can affect all EEE parts areas including modules, subsystems, and systems. Tasks are as follows:

- Identify and collect various data sources for EEE obsolescence for ISS and SSP Programs.
- Identify and document available tools and techniques for predicting obsolescence engineering.
- Research, compare, and benchmark various approaches to EEE parts obsolescence.
- Research and document data on decapsulating and repackaging companies and approaches, as well as their procedures, to maintain product reliability and quality assurance.

Benefit to NASA: Knowledge of predictive tools and methodologies comparison will aid EEE parts obsolescence evaluation for NASA projects. NASA will collaborate with other Government Centers such as DOD on methods to address obsolescence and obsolescence management (the defense industry is already researching these areas). Leads to the development of decision models and a part obsolescence management roadmap will be identified. Overall, maintenance, reliability, schedule costs, and sustaining engineering will improve.

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Reliability Analysis: EEE Parts Tools
POC: Jim Blanche, NASA JSC

Task Description: Reliability analysis predictive tools, such as MIL-HDBK-217, were intended to be used to compare reliability measurements of various hardware. For electronic components, the two most popular and widely accepted models are MIL-HDBK-217 and Telcordia, but other models such as PRISM are emerging in industry. Hardware performance on ISS shows that traditional predictive models are extremely conservative and unfairly penalize industrial and commercial parts. This task will identify and categorize predictive models used by other NASA Centers and leading industry contractors, summarize highlights of each tool, and develop guidelines on how and when to use the tool.

Benefit to NASA: Benefits include a consistent methodology and guideline for use of various predictive models and tools based on NASA, commercial, and aerospace survey results; and more realistic predictive methodology for industrial/commercial components. Flight customers such as OSP will need these guidelines as they emerge with new technologies not adequately addressed by standard MIL-HDBK-217 predictive methodologies.

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COTS Guidelines
POC: Dave Beverly, NASA JSC

Task Description: Industry continues to struggle with the use of COTS in military/aerospace applications. Individual COTS guidelines have been generated by various companies and agencies but are not collected into a central location useful for the Agency. This task will survey COTS guidelines and approaches used throughout industry, categorizing the approaches by commercial, military, and space applications. This task is confined to surveying industry and gathering COTS guidelines and approaches. Survey results will be centrally located for NASA use; common elements will be combined into one document section as applicable. Points of contact will be identified for each document.

Benefit to NASA: NASA users of COTS hardware will have a central location for various COTS approaches and guidelines. These guidelines provide a basis for the user to evaluate the COTS hardware for the application consistent with other COTS users.

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Parts Data Management BOK and Recommended Approaches
POC: Geoff Yoder, NASA JSC

Task Description: Parts database management is inconsistent throughout NASA. Some databases include failure history, others include as-built information but no evaluation history, while others include attributes such as component footprints. This task will survey NASA, military, and industry identifying the various approaches for EEE parts database management. At a minimum, each NASA Center and various contractors such as Boeing, Lockheed Martin, and Northrop Grumman will be surveyed to understand their various parts database management methods and techniques. The focus will be on EEE parts usage, an approval process for as-designed hardware, and historical maintenance of the data. The result of the survey will be a recommended approach for Agency coordination of EEE parts.

Benefit to NASA: Benefits include a study of designers' needs, identification of current databases, industry survey results, and increased leveraging of other NASA Center EEE parts evaluations.

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Architecture Evaluation
POC: Jim Blanche, NASA MSFC

Task Description: In this task, architecture working groups will be identified and summaries will made of their activities. Architecture experts will be identified at each Center, HQ Codes, and in other agencies. Current avionics systems and architectures in use for space/commercial applications will be identified focusing on parts/packaging/radiation assurance issues. Forecasts will be made for avionics architecture trends (near, mid, and long term), and those trends will be related to challenges to parts, packaging, and radiation assurance.

Benefit to NASA: This task will forecast parts/packaging trends to focus future work. It will help NASA understand risks and mitigation methods necessary for implementation of available architectures to minimize impact to reliability.

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Wiring Integrity
POC: Jim Blanche, NASA MSFC

Task Description: This task will:

- Assess wiring integrity issues and requirements for Space Shuttle Fleet, NASA aircraft, and other space vehicles.
- Perform trend analysis from discrepancy reports to determine the frequency of wiring integrity related problems (i.e., opens, shorts, damage).
- Assess current protection, inspection, training, and repair procedures and processes.
- Identify other practices, predictions, and testing techniques on wiring integrity that could be implemented by NASA.
- Leverage wiring integrity data, information, and solutions from DOD, FAA, industry, and others.

Benefit to NASA: This task will determine if aging, vibration, handling, or maintenance is creating or attributing to wiring integrity safety hazards. It will determine if current procedures and processes are adequate to mitigate wiring integrity issues for the life of the vehicles.

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Lead-Free Solder Survey: Body of Knowledge

POC: Jay Brusse, NASA GSFC

Task Description: The following work will be performed for this task:

- Perform a Technology Readiness Overview of lead-free solder.
- Summarize assembly and material characterization testing including alloys tested, results, and conclusions (maintain body of knowledge).
- Identify experts within Government, NASA, and industry.
- Recommend mitigation plans for lead-free implementation, including future testing if necessary.

Benefit to NASA: This task will summarize lead-free issues and compare/contrast previous and future test programs and results. The results will be used to guide in policy development, to develop Agency strategy, and to inform projects of potential lead-free solder impacts.

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Rad-Hard Testing of Mobile Routing Technology

POC: William Ivancic, NASA GRC

Task Description: The objective of this task will be to perform applicable radiation testing (primarily SEE and TID) on COTS-based mobile routing hardware and software and to effectively evaluate the extension of Internet-like functionality into space. NASA GRC/CISCO (via the Space Act Agreement) has developed an HD/SW package that would enable aero- and space-based nodes to maintain virtual connectivity to a secure intranet. Radiation-hard testing will help to determine near- and long-term effects of space on this technology.

Benefit to NASA: Testing will be a critical step toward increasing the survivability and establishing the performance characterization of COTS products in space. Effective demonstration of survivability and performance will enable new science gathering and knowledge paradigms to shift by allowing greater dissemination of information in near-real time through the use of space-based networks.

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Mixed-Signal Devices for Low/High Temperature

POC: Richard Patterson, NASA GRC

Task Description: Earth-orbiting and deep space planetary exploration missions require electronic components and systems that can operate reliably and efficiently in extreme temperature environments far below or above typical specification temperatures. These missions include Orbital Space Plane, ISS, Space Transportation System, Mars exploration rovers, JWST, Europa Obiter, and Mars Flyer.

This task, through collaborative efforts between NASA Centers and JPL, will establish a database of the reliability of mixed-signal devices for use in aerospace missions. This will be accomplished via thorough evaluation of mission-related devices under extreme temperatures and thermal cycling. Safe operating areas and degradation modes or failure mechanisms will be determined and used to establish risk factors for use of such devices in cold/hot space applications.

Benefit to NASA: Reliability assessment of mixed-signal devices under low/high temperatures and dissemination of this information will impact mission planners and system designers in terms of proper electronic component selection, optimal circuit design, and relaxed thermal constraints. This knowledge will result in simpler, more robust, lighter, and more reliable systems for space missions. These attributes will translate into low launch costs and increased payload capacity.

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Guidelines for Selection, Screening, Qualification, and Installation of Very Small Passive Parts
POC: Michael Sampson, NASA GSFC

Task Description: The passive part industry is continuously reducing component physical size and weight through innovative development of materials and processes. Component footprints as small as 20 mils by 10 mils (0201 chip size) are currently available. Despite the obvious benefits of reduced size and weight, these smaller devices are potentially more susceptible to handling and installation damage and may reduce design margins to levels requiring more effective screening, qualification, and derating. This task will review available tools/techniques for the proper selection, screening, qualification, and installation of very small passive parts (e.g., 0402 chip sizes and smaller). A set of guidelines will be published to provide NASA programs with information about the proper protocols to use with small passive parts.

Benefit to NASA: A reduction of integration and test failures attributable to improper handling/installation practices will be possible if written guidelines are provided to mitigate risk of such damage. Effective selection, screening, and qualification guidelines will help to ensure the reliability of the parts. Reliable use of very small passive parts will reduce the physical size and weight of flight hardware while increasing space available in the assembly for additional functionality.

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Advanced Polymer Electrolytic Capacitors
POC: Michael Sampson, NASA GSFC

Task Description: Commercial introduction of new polymer materials for use as the electrolyte in solid tantalum and solid aluminum electrolytic capacitors is underway. The polymer materials are a radical change from the electrolytes traditionally used. These new technologies promise to offer improvements in volumetric efficiency and performance. This task will review the published literature for both tantalum polymer and aluminum polymer electrolytic capacitors. Visits will be made to manufacturers. A technical report will be provided documenting the technology readiness level of both capacitor technologies. Recommendations will be made regarding additional analyses necessary to migrate these technologies to a readiness level suited for NASA applications. NASA projects/designers will be surveyed to identify the level of interest and applicability of these technologies to NASA systems.

Benefit to NASA: The polymer electrolytic capacitors may offer several performance advantages over the traditional electrolytic capacitors, including higher volumetric efficiency, reduced equivalent series resistance, better frequency response, and less catastrophic failure modes.

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Fiber-Optic Link Radiation Qualification Guide
POC: Steve Buchner, NASA GSFC

Task Description: Fiber-optic links are being used in multiple NASA space systems ranging from ISS to instruments such as GLAS. Qualifying a fiber link for radiation issues has challenges that are unique when compared to pure electrical systems. Differing test methods and engineering tools are required to support NASA needs from instruments to data movement to fiber gyros to phased array and free space communications. This task continues work that was begun in FY03 to document the known methods for radiation qualification and to provide lessons learned for future system qualification.

Benefit to NASA: The key benefit is in providing a standard guideline toward radiation qualification, thus enhancing mission reliability for those instruments and subsystems (CADH, FOG, Comm, etc.) that utilize fiber links.

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Sensor Technologies Radiation Effects
POC: Cheryl Marshall, NASA GSFC

Task Description: Sensor technologies for visible and X-ray imaging such as charge-coupled devices (CCDs) and active pixel sensors (APS), as well as those technologies being used in infrared arrays (IR), are of key interest for usage in science instruments and engineering systems such as star trackers. This task continues the highly successful task developing lessons learned on sensor technologies in order to provide NASA guidance for qualification/application of sensor technologies. CCDs are currently being documented. In addition, this task collaborates with technology developers (mostly DoD and industry funded) exploring hardening methods and technology models. For this latter, NASA provides beam and data analysis in exchange for other organizations providing NRE and data collection.

Benefit to NASA: Sensor technologies are clearly a major limiting factor in the ability of NASA to collect science data in space. Issues such as hot pixels, cosmic ray rejection, degradation, and lifetime, as well as remote instruments for robotics applications, have key challenges for meeting future science requirements. Engineering systems such as star trackers would also be critical users.

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Digital and Mixed-Signal ASIC Foundry Radiation Assessments
POC: Christian Poivey, NASA GSFC

Task Description: Application specific integrated circuits (ASICs) are commonly used in both spacecraft subsystems and science instruments. This includes digital, analog, and mixed-signal devices. These devices provide a savings in volume, power, and weight versus discrete designs and often provide a performance benefit for science accuracy or bandwidth. This task is in combination with a non-radiation task assessing ASIC foundries. The first step is to determine what radiation evaluation work has been done on current ASIC foundries both within and outside of NASA and to determine adequacy of radiation qualification procedures (test chips and/or structures). Once this is done, a round-robin multi-agency approach to provide periodic radiation assessments of COTS foundries will be developed.

Benefit to NASA: The prime benefit is providing NASA reliable techniques and selection criteria for ASICs. Albeit the use of FPGAs is becoming more widespread, there are still many applications that require ASICs (digital or mixed signal) for performance and mixed-signal issues. By providing a reference list of available foundry radiation data by process and updating by test on a yearly/bi-yearly basis (two to four per year), higher radiation reliability ASICs will be inserted into NASA systems.

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FPGA Radiation Testing
POC: Richard Katz, NASA GSFC

Task Description: FPGA (field-programmable gate array) technologies continue to advance commercially and are highly desired by NASA flight projects as either low-cost or schedule-effective alternatives to custom ICs such as ASICs. In this task, the test guideline development begun in FY03 will be completed, all available datasets on FPGA devices will be surveyed, new devices being developed of interest to NASA will be identified, and guidance to NASA flight projects will be provided for reliable utilization of varying types of FPGA devices such as one-time programmable (OTP) and reprogrammable.

Benefit to NASA: The prime benefit is to reduce risk of using these critical technology devices in NASA systems by providing guidance toward utilization and test in a radiation environment.

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ASIC Survey – Body of Knowledge
POC: Chuck Barnes, NASA JPL

Task Description: Application-specific integrated circuits (ASICs) are commonly used in both spacecraft subsystems and science instruments. This includes digital, analog, and mixed-signal devices. These devices provide savings in volume, power, and weight versus discrete designs, and they often provide a performance benefit for science accuracy or bandwidth. This task (in combination with a radiation task assessing ASIC foundries) will define NASA's technology needs for ASICs, as well as survey foundry capabilities. In addition, this task will identify approaches to ASIC qualification at the Agency and elsewhere and identify strengths and shortfalls that may require further work (such as a new qualification guideline). Questions such as how reduced Vcc and feature size impact ASIC qualification and design will be explored.

Benefit to NASA: The benefits of ASICs are clear, but the drawbacks tend to be design and fabrication costs as well as potential long-pole schedule issues. This task will define critical technology and resource needs and availabilities that will aid flight projects in selecting reliable foundries and appropriate qualification mechanisms. Flight customers such as the James Webb Space Telescope (JWST), JIMO, and the

Orbital Space Plane (OSP) will benefit greatly.

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Radiation Survey of Wide-Bandgap Microelectronics
POC: Tim Oldham, NASA GSFC

Task Description: Wide-bandgap (WBG) semiconductors such as GaN have the potential to revolutionize RF and power systems for NASA by providing high performance with a system reduction in power and weight. In addition, performance parameters would exceed current capabilities. This task focuses on supporting NASA interests in WBG at locations such as GRC, as well as discussing future partnering and efforts at DoD (NRO and DARPA, for example) by developing a TRO on the technology and radiation effects characteristics.

Benefit to NASA: WBG is on a direct path for insertion into NASA systems. Reduction in risk on this path is proposed by documenting known properties and potential issues.

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Radiation Effects Qualification of ADCs
POC: Heidi Becker, NASA JPL

Task Description: Mixed-signal devices, such as analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), have continued to advance to a very high bit count (up to 24), while adding additional functions within the chip (e.g., sample-and-hold, references, etc.). Flight projects have been seeking to use higher accuracy and higher speed devices with additional functionality. However, due to the nature of ADCs and DACs, radiation performance can often be a limiting factor for device usage and applicability. This task focuses on documenting the existing knowledge base of radiation effects on ADCs and DACs, including test methods for qualification. Identification of knowledge gaps for future research efforts will be included.

Benefit to NASA: The prime benefit will be providing direct selection and qualification guidance for NASA flight projects.

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Radiation Effects on SiGe Microelectronics – Mixed-Signal Technology and Hardening Efforts
POC: Robert Reed, NASA GSFC

Task Description: SiGe microelectronics is a commercially available high-speed, mixed-signal technology applicable to instrument, RF, and potentially widespread systems. In FY03, novel radiation test techniques for high-speed technologies were developed, as well as collaborative test chips (including DoD-funded hardening methods), radiation effects data, and modeling. Self-test circuit (STC) is the test technique, which is now considered the baseline method for evaluation by DoD, university, and others for high-speed technologies. In FY04, this effort will be continued by:

- Testing IBM 7, 8, and/or 9 hp commercial processes, unhardened and hardening solutions funded by DoD using STC.
- Modeling of technology for radiation effects and combined temperature effects.

Benefit to NASA: SiGe is now being applied to RF and instrument systems in NASA (GRC, JPL, and GSFC) and can be advantageous in terms of increased system performance. Radiation (single event) is the main concern. This task will provide the independent assessment of the unhardened and potentially hardened solutions using skills and capabilities unique to NASA GSFC.

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Radiation Effects on COTS Volatile and Nonvolatile Memories
POC: Leif Scheik, NASA JPL

Task Description: Memories are one of the most ubiquitous electronic components in NASA space and avionic systems. From the foundry side, they are also usually among the first to migrate to new technologies, scaled feature sizes, etc. This task seeks to use both sides of this equation: to utilize COTS memories for radiation evaluation of scaled feature size, new dielectrics, and thinner gate oxides, and to provide guidance for NASA projects in the use and application of memories in NASA systems. Per issues such as soft-error rates (avionics), single-event modes, and scrubbing techniques, JPL will focus on trending DRAMs and flash, while GSFC will focus on application techniques for customers (i.e., what projects should be doing to use devices reliably).

Benefit to NASA: Memory usage is widespread, and needs vary greatly from NASA mission to mission. Guidance by class of mission can aid projects in reducing risk by making smarter design and technology choices. In addition, the advanced examination of COTS emerging technologies in memories provides a snapshot for other devices such as processors.

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Guidance for 0201 Passive Technologies
POC: Reza Ghaffarian, NASA JPL

Task Description: Design guidance will be developed for miniature 0201-sized passives, recently introduced by industry. Initially a TRO will be generated using industry input, as well as lessons learned in 2003 from one design being used by the JPL lead consortium. Testing will be performed when funding becomes available.

Benefit to NASA: Passive technologies are widely used by NASA for all missions including the Space Shuttle, the James Webb Space Telescope (JWST), Mars missions, etc. Tiny 0201-sized passives become the next choice. Understanding key design, quality, and reliability is needed for low-risk insertion into NASA projects.

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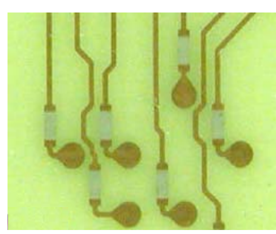
Embedded Passives
POC: David Gerke, NASA JPL



Task Description: The integrity and functionality of embedded resistor materials, and the interfacial strength between the resistive material and the associated printed wiring boards (PWBs), have not been fully explored for potential space electronics applications. The reliability of this technology needs to be thoroughly and carefully studied before implementing it for space electronics. A Technology Readiness Overview (TRO) will be conducted, as will a complete reliability assessment testing of FY03 test vehicles.

Benefit to NASA: This technology will allow NASA programs and projects to reduce the weight and size required for electronic assemblies within systems by building functioning circuitry into printed circuit boards (PCBs) and/or substrates using embedded passives. The use of embedded passives will increase the overall reliability by reducing the total number of solder joints per assembly.

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Photonics Survey: Body of Knowledge

POC: Chuck Barnes, NASA JPL

Task Description: Optoelectronics and photonics cover a diverse range of technologies, many of which are attractive for NASA flight project applications. Space applications vary from simple optocouplers for ground isolation to on-board fiber-optic data links to sophisticated interferometric applications in science instruments. While this wide range of potential applications makes photonics a desirable technology area, it also results in an inherent difficulty tracking photonic technology development and all the existing and potential applications in NASA's diverse mission set. In this sense, photonics is similar to MEMs and nanotechnology. The objective of this task is to survey, track, and report on existing and potential photonics applications in NASA flight systems. Achieving this objective will then allow this information to be provided to all potential NASA users, which will facilitate and maximize the insertion of photonics technologies in NASA systems. In addition to the survey of NASA, other high-reliability users of photonics will be surveyed whose performance and environmental requirements are synergistic with those of NASA.

Benefit to NASA: This task will benefit NASA by facilitating the insertion of photonic technologies in NASA flight engineering systems and instruments. Potential NASA users will be identified and informed of the potential application areas for existing photonics and also of the state of readiness for application of these technologies in the space environment.

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COTS/PEMs Guideline Development and Completion of Package Testing

POC: Michael Sandor, NASA JPL

Task Description: The COTS PEMs task for FY04 will complete the package evaluations on five different devices from five different vendors. PEMs packages are designed for modern automated board assembly-houses, which employ surface-mount technologies for device assembly on the printed circuit boards. The commercial industry controls board assembly to a few degrees above melted solder. NASA contractors, on the contrary, usually build only two boards (one for EM, one for FM), and because of this low quantity they use cost-effective hand-soldering techniques. This exposes the plastic parts to uncontrolled temperatures that exceed the cautionary notes found in most PEMs data sheets. This important evaluation will identify the thermal stresses and failure risks of PEMs parts assembled using typical NASA soldering processes. In addition, temperature cycling and HAST will be performed on all five types.

Benefit to NASA: The results of the NASA COTS PEMs package evaluation will be incorporated into the PEMs Guideline document, which will provide the latest available data, information, and risks associated with using COTS/PEMs in space flight applications. Recommendations and alternatives to mitigate risk will be made. This knowledge will reduce incidence of possible failures and increase NASA hardware reliability. The guideline will be an integral part of establishing a NASA COTS PEMs database and repository of information for NASA engineers and project managers.

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FPGA Body of Knowledge: A Comprehensive Survey of High-Density FPGAs for Space Applications
POC: Ramin Roosta, NASA JPL

Task Description: High-density FPGAs (both one-time programmable and reprogrammable) are commonly used in most NASA projects. However, these COTS devices are a major source of reliability concerns for harsh space environments. This task will explore the reliability and radiation issues associated with these devices. The research will provide a complete survey of five major manufacturers of FPGAs such as Xilinx, Actel, Altera, Quick Logic, and Lattice. The task will provide a guideline as to which FPGA technology to select for various NASA projects given their reliability/radiation requirements. A list of follow-up tests also will be given for various FPGA technologies. The task Principal Investigator's previous work on FPGA TRO will directly lead and assist in this research.

Benefit to NASA: Each NASA mission has a specific reliability requirement; the result of this survey will assist all NASA projects in using this advanced technology to enable selection of the appropriate FPGAs for their design.

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Burn-In for FPGAs/ASICs: Body of Knowledge
POC: Ramin Roosta, NASA JPL

Task Description: Field programmable gate arrays (FPGAs) and ASICs are utilized in almost all deep space and planetary exploration missions, which need to operate reliably under extreme temperature and radiation environments. Three major testability requirements are stuck-at-fault coverage, at-speed testing, and IDDQ testing for CMOS-based chips. Generally speaking, 98% or higher for stuck-at-fault and 99% node toggle coverage for IDDQ testing is accepted as military/space standard. These requirements are subject to debate in both commercial and military industry. Another issue regarding ASIC testability that is subject to debate is the fault-coverage requirement of individual blocks within the ASIC in order to satisfy the overall fault coverage. As smaller geometries are approached (0.13 micron and below), there is discussion within the industry about the value of at-speed fault models such as transition and path-delay. The general consensus appears to be that in addition to high stuck-at-fault coverage, there is a definite need for at-speed testing to detect actual defects. There is also a general consensus that the value of IDDQ testing will become lesser in the smaller geometries. This research concentrates on a survey of practices used by different NASA Centers, commercial industry, and aerospace/military industry while assessing the effectiveness of IDDQ test for nanometer technology.

Benefit to NASA: The result of this survey will assist all NASA missions and projects in determining the required and acceptable fault coverage, as well as suitability and effectiveness of IDDQ and at-speed testing for FPGAs/ASICs. There will be a clear understanding as to what the acceptable coverage must be. A second benefit is a unified NASA-wide testability requirement.

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Programmable Oscillator Evaluation and BOK
POC: Shri Agarwal, NASA JPL

Task Description: The main objective of this task is to explore infusion of COTS programmable oscillators into NASA projects. With the programmable oscillators, a large quantity of blanks can be procured and then programmed to work at a desired frequency, voltage, output level, etc. This is a highly leveraged task. The focus is on low-power parts (3.3 V and lower operational voltage). Total Ionizing Dose (TID) radiation testing is in progress at NASA GSFC. The programmable oscillator task for FY04 will complete the reliability evaluation of current product for flightworthiness, including complete data analysis and a report. The evaluation tests will include construction analysis, burn-in testing requirements (including pre- and post-programming burn-in testing), data retention testing, temperature cycling, random vibration testing, and life testing.

Benefit to NASA: Fixed-frequency custom hybrid parts will be replaced, which will greatly reduce schedule and cost; projects can rely on "instant" delivery versus an 8-month delay, and the resulting cost will be <$100 for programmable oscillators versus $2,000 for the current qualified product. In terms of flexibility, the task allows single common buy and qualification of oscillators that could be put in NASA inventory and individualized by specific users. Also, the low power consumption models are available with 3.3 V and 2.7 V options.

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Advanced Processors Technology Assessment
POC: Doug Sheldon, NASA JPL

Task Description: A wide variety of processor requirements exist in NASA missions. Often these requirements can be met by more than one type of processor. This task will provide a technology assessment of the most current new entrants to the market, while providing a bridge to currently space-qualified products. This will include PowerPC, ARM, MIPS, and other new market entrants. The following work will be performed for this task:

- Benchmark NASA-wide processor procurement and evaluation procedures.
- Determine knowledge gaps in vendor, literature, and NASA data as it relates to performance and possible NASA mission-related failure modes.
- Comprehend architectural and technology variations as they relate to space applications.
- Quantify current packaging materials and thermal management options for improved performance.
- Quantify industry best practices in terms of both quality systems and reliability standards implementation. Include possible evolutionary steps from existing military standards.
- Compare off-the-shelf, PC-based hardware and software test tools to technology-specific and custom-built testers.

Benefit to NASA: Guidelines will be provided that encompass NASA community commonalities while recognizing site- and mission-specific uniqueness. A uniform knowledge base and NASA site cross-fertilization will be enabled. Groundwork will be laid for possible low-cost functional testing methodologies and alternatives.

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Commercial SOI Microprocessor: Test and Radiation Test Guideline
POC: Allan Johnston, NASA JPL

Task Description: A radiation test guideline will be developed concentrating on SEU effects, but will also address total dose effects. A survey of test methods by all organizations will be undertaken and documented. Methods of distinguishing crashes in the operating system from functional errors in the processor will be included, along with approaches for evaluating the effect of internal transients at high clock speed. The guideline will use existing data on commercial and radiation-hardened microprocessors, including test results for the RAD6000 and RAD750, PowerPC, and Pentium families. It will also include recommendations for error visibility, which are essential to calculate upset rates in space applications.

Benefit to NASA: The prime benefit is providing a common reference for radiation tests on these complex devices. This is a critical issue, even for radiation hardened processors, because the interpretation of test data is ambiguous without an accepted test method.

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Analog-to-Digital Converters: Body of Knowledge
POC: Shri Agarwal, NASA JPL

Task Description: This task will focus on analog-to-digital converter (ADC) parts survey. The survey will involve the following:

- Discussions with users at various NASA Centers to determine their immediate and future needs as far as the resolution (number of bits), speed, operational voltage, power dissipation, etc. Information on type of mission (instrument versus spacecraft), mission length, radiation, and temperature requirements will be gathered as well.

- Discussion with manufacturers of ADC parts, including COTS PEMs ADCs. This will entail getting status of current products and their future plans.
- Matching of NASA needs with parts availability. Any gaps between the two will be identified. Also, where possible, recommendations will be made on how to make the parts useable (thereby closing the gap), such as by conducting further tests, etc.
- Publish report and TRO.

Benefit to NASA: The NASA ADC task will provide a useful snapshot of the types of ADC parts needed to satisfy various applications across the Agency. The vendor survey will identify the parts that can be used on flight as is and provide an assessment of the amount of effort required to evaluate other available parts for flightworthiness. This task will steer NASA to use common approaches wherever possible.

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COTS DRAMs: Body of Knowledge
POC: Michael Sandor, NASA JPL

Task Description: The proposed task will provide a technology assessment of current state-of-the-art volatile memory (dynamic random-access memory [DRAM] and SDRAM) products by benchmarking current industry volatile memory procurement and evaluation procedures; determining knowledge gaps in vendor, literature, and NASA data as it relates to performance and possible failure modes; quantifying industry best practices in terms of both quality systems and reliability standards implementation; and including possible evolutionary steps from existing military standards.

Benefit to NASA: NASA guidelines will be provided for the infusion of reliable volatile memory into upcoming missions. A uniform knowledge base and NASA site cross-fertilization will be enabled. Groundwork will be laid for possible low-cost functional testing methodologies and alternatives.

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Solid-State Relays
POC: David Beverly, NASA JSC

Task Description: Solid-state relays continue to increase in efficiency and power-handling capabilities but are not yet proven for critical space flight applications. This task will survey the contractor base to determine uses and difficulties of solid-state relays in various applications, collect data from vendors, and characterize the readiness level of the various solid-state relays.

Benefit to NASA: The use of solid-state relays eliminates contact problems currently associated with mechanical relays. The survey results will provide a basis for projects to determine if solid-state relays are applicable for the given application. Projects such as ISS, Shuttle, and OSP would benefit as vendors for mechanical relays continue to discontinue their space products.

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MEMs/MOEMs/Nanotechnology
POC: David Beverly, NASA JSC

Task Description: The following work will be performed for this task:

- Determine the current status of MEMs worldwide and develop a MEMs catalog to facilitate injection/interaction of designers with the MEMs community.
- Establish a cooperative framework with external organizations to utilize their expertise.
- Develop training capability to familiarize personnel with the technology and demonstrate benefits to JSC.
- Determine EA GFE candidates for MEMs infusion.
- Identify packages for near term insertion in projects.
- Develop in-house design, development, and testing capability.

The proposed NEPP activity is the augmentation of ongoing MEMs/nanotechnology data-gathering activities. The combined outcome of NEPP and existing investigation and research activities is the cataloging of industry available data and associated TRL.

Benefit to NASA: The proposed NEPP activity of MEMs/MOEMs investigation and research combined with the ongoing JSC activities provide a single source of MEMs/MOEMs/nanotechnologies and TRL levels. Significant functionality, cost, and weight will be achieved with use of this technology.

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Microcontrollers and Digital Signal Processors Survey
POC: Geoff Yoder, NASA JSC

Task Description: Distributed architectures typically require less computational power than centralized architectures, and they rely on microcontrollers and digital signal processors (DSPs). DSPs and microcontrollers are the backbone for disciplines such as robotics and the automotive industry, but they have limited space applications. This task will focus on surveying industry for both DSPs and microcontrollers to determine availability, issues, and TRO for space applications.

Benefit to NASA: This task will increase NASA capabilities for distributed architectures, sensors, and robotics applications. Results from this study will provide projects such as the Orbital Space Plane (OSP), the International Space Station (ISS), and SLEP with a starting point.

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Wireless Sensors and Life Cycle Prediction, Health, and Utilization Monitoring System
POC: NASA LaRC

Task Description: This task will evaluate the real-time or near-real-time assessment of equipment condition obtained from embedded sensors and/or external tests and measurements using portable equipment. Current plans are to instrument (wireless) a remote control vehicle with several types of sensors as a proof of concept. A Compaq iPAQ will be used for monitoring the vehicle sensors.

Benefit to NASA: The benefits of this task will be automation of the platform-monitoring process, continuous monitoring of the platform, and enabling monitoring of the platform blind spots and complete platform health history in a database.

MEMs and Electret Microphone Technology Assessment
POC: NASA LaRC

Task Description: Field measurement of noise radiated from flight vehicles is an important element of aircraft noise research programs. NASA (Langley and Ames) have been involved for the last three decades in the development of acoustic measurement systems to support the NASA noise research programs. The new challenge for vehicle operational noise reduction through varying glide slope and flight paths requires noise measurement to be made over an array of microphones with large area under the vehicle flight path. In addition, a large aperture directional array using hundreds of flush-mounted microphones can be constructed to obtain high-resolution noise localization maps around airframe model. A unique logarithmic spiral layout design can be chosen for aeroacoustic testing. So far, for all these measurements B&K microphones are being used. Each B&K microphone costs more than $1.7K. During the last 2 years, new MEMs and electret microphone technologies have emerged and are available in the market. However, researchers are reluctant to replace B&K microphones with these economical microphones, as these have not been tested thoroughly. The purpose of this task is to purchase these microphones and characterize them thoroughly (frequency range, harmonic distortion, sensitivity, and environmental affect including temperature, humidity, and air speed).

Benefit to NASA: The number of commercial aircraft flights has grown for decades and is expected to increase steadily in the future. To measure exact source of noise, a larger and more dense array of microphones is needed. If MEMs and recently designed electret microphones can provide data as good as B&K microphones, it will save industry and NASA millions of dollars per year.

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Embedded Actives
POC: Mark Strickland, NASA MSFC

Task Description: The following work will be performed for this task:

- Identify commercial resources for embedded actives and who is using or researching the technology.
- Assess previous test programs.
- Determine technology readiness levels (TRL).
- Document advantages/disadvantages for NASA use.
- Recommend future work.

Benefit to NASA: This task will determine the current state of embedded actives research and document potential benefits to NASA.

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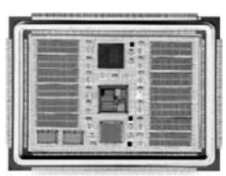
Evaluation of 3D Multichip Modules
POC: Jim Blanche, NASA MSFC



Task Description: The following work will be performed for this task:

- Evaluate commercial state-of-the-art technologies in 3D multichip module (MCM) packaging that utilize multiple substrates and die stacking.

- Capture knowledge from users of 3D devices (e.g., Air Force, GSFC).
- Analyze information to determine technology readiness level (TRL) for NASA applications.
- Identify missing data relevant to NASA-specific requirements.
- Examine current research activities in 3D MCM packaging for potential future use by NASA.

Benefit to NASA: 3D multichip module packaging provides advantages in reduced volume and weight while increasing electrical performance by reducing signal propagation lengths, and increasing reliability by reducing interconnections.

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Lead-Free Solder Alloy Characterization
POC: Wayne Johnson, NASA MSFC

Task Description: The following work will be performed for this task:

- Continue to characterize the microstructure and measure the mechanical properties of the lead-free solders being studied by the Joint Group on Pollution Prevention (JG PP) as a function of compositional variation.
- Measure the creep properties of Sn-Ag-Cu and Sn-Ag-Cu-Bi alloys as a function of composition.
- Characterize the microstructure and the tensile, fatigue, and creep properties of Sn-Cu as a function of composition.

Benefit to NASA: The work of this task will complement the JG PP assembly-level testing of these alloys, and ensure that compositional variations, intentional (for cost or patent reasons) and unintentional (manufacturing tolerances), do not present a significant reliability risk.

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Lead-Free Solder Survey BOK
POC: Jim Blanche and Mark Strickland, NASA MSFC

Task Description: The following work will be performed for this task:

- Perform a Technology Readiness Overview of lead-free solder.
- Summarize assembly and material characterization testing, including alloys tested, results, and conclusions (maintain body of knowledge).
- Identify experts within Government, NASA, and industry.
- Recommend mitigation plans for lead-free implementation, including future testing if necessary.

Benefit to NASA: Task results will offer a summary of lead-free issues and compare/contrast previous and future test programs and results. These results can be used to guide policy development, to develop Agency strategy, and to inform projects of potential lead-free solder impacts.

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Laser Diode Reliability BOK
POC: Melanie Ott, NASA GSFC

Task Description: Laser diodes are key components of Lidar and communication systems. They are used as the power source for communication transceivers and are used to pump high-power lasers and fiber lasers for science data instrumentation. Failure of these components results in failure of the instrument or system. Laser diode components are commercial off-the-shelf products at this time. Although some reliability issues are understood at the wafer level, the lack of knowledge related to the issues of packaging are still causing failures on space flight instrumentation. Recently, ICESAT experienced failures due to this lack of sufficient knowledge. This task will focus on providing guidance and information related to the reliability of laser diodes to avoid future failures and ease usage of these components into space flight systems.

Benefit to NASA: This task will provide the necessary guidance to usage and reliability of laser diodes such that systems depending on these components will function adequately throughout the life of the mission. There is an extreme lack of sufficient information on this subject, particularly that related to the higher power devices in which the failure modes are more pronounced. Recently it has become apparent that this area of photonics must be investigated to avoid further failures such as ICESAT.

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Wireless Sensing for Health Monitoring
POC: Liangyu Chen, NASA GRC

Task Description: High-temperature wireless sensing and data transferring systems are critical to the next generation of aerospace engine technology with self-monitoring and self-control capabilities. The high-temperature RF wireless sensing and data transferring system will enable engine environment *in situ* sensing and reduce the electrical wires, inter-connectors, and mounting hardware. Besides the weight/fuel savings, replacing these wires and related hardware with a wireless system directly improves the overall reliability of the electronic engine control system. An *in situ* sensing system for engine combustion processes provides real-time physical information about combustion for optimization and safety monitoring operations. The high-temperature operable wireless system can eliminate the massive wiring between the testing engine and the ground data recording systems. High-temperature radio frequency packaging technology is essential to enable this emerging technology.

Benefit to NASA: This task will enable high-temperature wireless sensing and data transferring in engine environment for health monitoring to significantly improve overall engine performance and long term reliability. It will also improve testing efficiency.

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Evaluation of High-Temperature Packaging Module for Implementation of SiC Wide-Bandgap Microsystems
POC: Liangyu Chen, NASA GRC

Task Description: This task will finish validation of a spark-plug type packaging module for high-temperature silicon carbide (SiC) sensors and electronics. SiC has been established as a high-temperature electronic and MEMS sensor material. Previously, NEPP supported successful validation of packaging subcomponents for high-temperature applications. The task activity includes integration of these packaging subcomponents to form a multi-purpose packaging module for SiC MEMS sensors with signal conditioning electronics, followed by long-term reliability validation and relevant aero-propulsion engine environment testing. The high-temperature sensors and electronics enable measurements of acoustic, temperature, pressure, and other physical parameters in high-temperature environments, therefore benefiting missions to Venus, space and aero propulsion systems with active control, and launch vehicles.

Benefit to NASA: This task will enable implementation of SiC high-temperature sensors and electronics, high-temperature sensing and signal processing for inner solar space missions, and active control of space and aero propulsion systems.

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Area Array Packages BOK
POC: Mark Strickland, NASA MSFC

Task Description: The following work will be performed for this task:

Collect and evaluate results and recommendations from the Cockpit Avionics Upgrade (CAU) BGA certification process study.
Review area array certification processes at other NASA Centers.
Develop a guideline document for process evaluation of certifying area array packages for future flight use.
Develop and maintain a database of reliability testing on area array packages.
Develop tools to assist in area array package implementation.
Create a Web page through GSFC IMD to store area array package data and points of contact.

Benefit to NASA: This task will standardize the process evaluation of area array packages for flight use, enhance understanding process and QA indicators for reliability, and provide guidelines for process evaluation and area array packages.

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